OPTIMIZATION OF SUBCRITICAL AND TRANSCRITICAL ORC'S FOR LOW TEMPERATURE HEAT SOURCES

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ABSTRACT

Many types of low temperature (100-150°C) heat sources exist: waste, geothermal, solar, ... Classical, water-based power cycles cannot convert this heat into electricity efficiently. For these heat sources an Organic Rankine Cycle (ORC) is the better choice. In this paper, the thermodynamic optimization of ORC's for low-temperature heat sources is discussed and transcritical cycles are compared to subcritical cycles.

In the literature, different efficiencies (energetic, exergetic, ...) are defined. For economic reason, it is concluded that the total *plant* efficiency should be maximized and not the *cycle* efficiency as is often done in the literature. This is because the latter efficiency does not take into account the heat source cooling.

On our search for optimum plant designs, we investigated both subcritical and transcritical ORC's. The advantage of the latter cycle is that the fluid does not pass through the two-phase region during heating, so a better fit between the working-fluid heating curve and heat-source cooling curve is achieved. Less irreversibilities are generated in the heat exchange and higher efficiencies can be obtained.

The simplest ORC configuration is compared to cycles with a recuperation heat exchanger and to cycles with turbine bleeding. It is concluded that these two extended cycles are only useful when a limit on the heat-source-outlet temperature exists.

The optimum working fluid depends strongly on the heat source inlet temperature and the optimum cycle is often of the transcritical type. With a careful choice of the working fluid exergetic plant efficiencies of 50-60% can be achieved.

Due to the low temperature of the heat source, both the plant and cycle efficiency decrease strongly with increasing condenser temperature and pinch-point-temperature difference. So for low-temperature heat sources, a low condenser temperature and low pinch-point temperatures are even more important than in classical power plants.

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